Biomatter 2:4, 237–238; October/November/December 2012; © 2012 Landes Bioscience

Porous-based biomaterials for tissue engineering and drug delivery applications

Hélder A. Santos

Division of Pharmaceutical Technology; University of Helsinki; Helsinki, Finland

The current research on micro- and nano-biomaterials is expected to have an enormous impact on human health care. The applications include medical devices, diagnostics, sensors, drug delivery systems, and tissue/bone engineering. Drug delivery systems should be biocompatible allowing for high payloads of drug molecules without premature drug release, be site specific for targeting delivery, and release the drug at a controlled rate reaching effective local drug concentrations with the fewest side effects possible. In addition, tissue engineering, particularly regenerative medicines, is a newly emerging field which aids and increases the repair and regeneration of deficient and injured tissues/organs. Synthetic, natural and inorganic porous-based biomaterials can be used as e.g., drug carriers and scaffolds for tissue/bone engineering therapies and for locally control the dose and duration of the release of drug molecules. Altogether, this special issue will hopefully provide knowledge on the advances and most recent porous-based biomaterials, scaffolds and other technologies intended to develop precisely tissue/bone engineered and drug delivery systems. Several examples of the methods of preparation, characterization and applications of these materials are also presented and discussed in detail in this issue.

In this special issue of *Biomatter* several examples of porous-based biomaterials used for tissue engineering and drug delivery applications are presented. Five special focus reviews and three special focus reports highlight and describe in detail some of the most recent methodologies and strategies to develop porous-based biomaterials for biomedical applications.

The introductory review article by Elsner and colleagues (p. 239) describes in detail a freeze drying of inverted emulsions method for preparation of drug-eluting porous structures for various biomedical applications. This methodology enables the incorporation of any drug to obtain an "active implant" that releases drugs to the surrounding tissue in a controlled desired manner. The release profiles of both water-soluble and water-insoluble drugs are affected by the emulsion's formulation parameters. For example, the release profile is affected mainly through the emulsion stability and the resulting porous microstructure for water-soluble drugs, whereas for water-insoluble drugs the release mechanism occurs via water uptake and degradation of the host polymer.

In the subsequent review article, Shue and Yufeng (p. 271) summarize the main challenges and methods in regenerative periodontal therapy, including scaffolds for tissue regeneration based on ceramic and polymer biomaterials, as well as membranes used for periodontal treatment and their impacts on the experimental/clinical management of periodontal defect. Few examples of polymers used as barrier material in guided tissue regeneration are given, and the combination of certain polymers periodontal ligament and alveolar bone cells repopulation of the defects are discussed.

The review paper by Silva and colleagues (p. 278) highlights the biomedical applications of marine algae sulfated polymers, in particular on the development of innovative systems for tissue engineering and drug delivery approaches. It is emphasized that the potentialities of such biomaterials for modulation of cellular behavior and thus on tissue regeneration, but although with great biological potential there are still several steps in basic and preclinical research before clinical trials of these materials come to the fore, particularly in terms of the production of polysaccharides in a reliable, reproducible and sustainable way.

Next, Kasuya and Tanishta (p. 290) review a novel liver tissue engineering approach using microporous membranes used not only for construction of 2D tissue units, but also to assemble these 2D tissue units into functional 3D liver tissues in vitro. The control of the cell behavior and tissue organization using this approach can be achieved by controlling the membrane geometry, and cell-dense thick tissues can be reconstructed by layering cells cultured on biodegradable microporous membranes.

In the last review article, Shahbazi and colleagues (p. 296) provide a comprehensive overview on the recent developments and potentials of mesoporous materials (silica and silicon) nanoparticles for targeted drug delivery. Due to the suitable physicochemical properties of these materials, large amounts of drugs can be controllably loaded into the pores of the materials, allowing also coupling of homing molecules to facilitate active targeting. Several examples on the great research advances in mesoporous material research are presented, with particular emphasis on in vitro and in vivo studies. Despite the promising biomedical application of these materials a deep understanding on the in vivo biocompatibility/toxicity and in vivo fate is still needed to be assessed in the future.

The first original paper by Fuchigami and colleagues (p. 313) demonstrates that nano-sized capsular structures and ultrathin shells can be applicable as a drug carrier in magnetically guided drug delivery systems. The diameter of FePt capsules changes by adjusting the size of the silica template particles and the shell thickness (10 nm) and by adjusting the amount of FePt nanoparticles accumulated on the silica template particles. In addition, hybrid

Correspondence to: Hélder A. Santos; Email: helder.santos@helsinki.fi
Submitted: 11/27/12; Accepted: 11/27/12
http://dx.doi.org/10.4161/biom.23024

and network capsules show magnetization and are expected to exhibit superparamagnetic behavior at approximate body temperature. When lipid-coated FePt network capsules are loaded with anticancer drug, doxorubicin, the cellular toxicity increases.

The second original research article by Lin and Wang (p. 321) presents an alginate hydrogel produced into a fibrous structure by manipulating the operating parameters in a wet-spinning system for preparation of skin wound dressings with different properties. The precise control of those operating parameters has a tremendous impact on the size of the fibers and the fibrous structure, and they also affect the performance of the dressings in terms of e.g., drug release, swelling and bacterial inhibition potential.

In the third original research paper, Fonte and colleagues (p. 329) analyze the influence of cryoprotectants on PLGA nanoparticles' stability and porosity after freeze-drying. With this approach, the number of pores on the PLGA nanoparticles' surface significantly increases, particularly when cryoprotectants are added. The porosity of the nanoparticles and the presence of sugar-based cryoprotectants on the nanoparticles' surface affect the release of insulin from the nanoparticles. For example, after freeze-drying, the release of the encapsulated insulin increases ca. 18% in the first 2 hours due to pore formation, maintaining a sustained release thereafter. The amount of insulin released is higher in the presence of cryoprotectant trehalose and lower for sucrose, glucose, fructose and sorbitol.

The reports presented in this issue highlight the great potential of porous-based biomaterials, from natural or synthetic sources, in a wide range of biomedical applications, including tissue regeneration and drug delivery. Current knowledge on the pre-clinical development, characterization and application of these biomaterials can be used to predict their potentialities in vivo. Some strengths and weaknesses of the presented materials and their applied approaches have been presented and discussed. However, it is clearly highlighted that the applicability and the results from such biomaterials needs more clinically-oriented studies in the future in order to confirm or dismiss the pre-clinical remarkable potentialities of these materials in biomedical applications. Nevertheless, the current findings and applicability of the materials discussed herein are already rather encouraging for further tailoring toward clinical translation.

Finally, I would like to take this opportunity to express my deepest thanks, as the Guest Editor of this special issue for *Biomatter*, to all the contributing authors and reviewers for their great efforts in helping putting together this issue. I sincerely hope that the content of this issue can provide current and further knowledge on the wide application and development of porous-based biomaterials in the fields of tissue engineering and drug delivery. I also hope that the contributions published herein will be of wide interest to the readers of the journal.